MANAGING EXCHANGE RATE CRISES:
EVIDENCE FROM THE 1890's

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ABSTRACT

    This paper investigates the effectiveness of the monetary
authority's borrowing policies in resolving exchange rate crises.   It
shows why obtaining loans or lines of credit in foreign currency may
avoid, at least temporarily, the devaluation of a fixed exchange rate,
and discusses the problem of the optimal size of the loan and/or the
line of credit.   The analysis focuses on a particular episode of foreign
exchange rate pressure, during the troubled years between 1894 to 1896.
The results suggest that the borrowing policy followed by the U.S.
Treasury in those years was effective in avoiding the collapse of the
United States' gold standard, and that the amount of the borrowing
undertaken by the Treasury might have been optimal.

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Introduction

Exchange rate crises have recently received considerable attention. Theoretical research started by Krugman [1979] and expanded by Flood and Garber [1984], Grilli [1986], Obstfeld [1986] among others, has stressed the relationship between collapses of fixed exchange rates and speculative runs on the international reserves of the monetary authorities. Empirical application of these models has been attempted by Blanco and Garber [1986] for the case of the recurrent devaluation of the Mexican peso during the 1970's and the early 1980's. Exchange rate crises, however, are not a recent phenomenon; rather they have characterized the history of the international monetary system. The abandonment of the gold standard at the start of World War I, the progressive deterioration and definitive breakdown of the gold exchange standard in the early 30's, and the numerous readjustments of the exchange rates during the the Bretton-Woods period demonstrate how exchange rate crises are not a unique characteristic of contemporary exchange rate systems.

An interesting empirical problem is to analyze how monetary authorities have behaved when faced with such exchange rate emergencies. Typically, in these circumstances, foreign exchange authorities have tried to borrow international reserves. In this paper I show why obtaining a line of credit in foreign currency may be an effective policy in order to avoid a devaluation, and I discuss how to determine the optimal size of the loan. This is done through the study of a particular episode: the exchange rate crises of 1894-96. There are

several reasons that justify the choice of this specific incident.
First, because of a subsequent Congressional investigation, we have a
complete and detailed record of the actions undertaken by the Treasury
at that time. Second, it is interesting to see how certain policies,
typical of today's central bank operations, were already known and used
in times when a central bank did not exist.

The structure of the paper is as follows. In section I the
essential economic and institutional environment of the period is
reviewed. Section II models the relationship between borrowing and the
viability of a gold standard. In section III the framework developed in
section II is used to study the exchange rate crisis of 1894-96.
Section IV analyzes the issue of the optimal amount of foreign exchange
loans, and applies the result to examine the characteristics of the
Treasury borrowing operation of February 1895. Section V concludes.

I The Essential Institutional and Economic Environment of the Period[1]

After January 1, 1879, as prescribed by the Resumption Act of June
14, 1875, legal tender paper money had to be redeemable in coins. Even
if "coin" meant, at the time, either gold or silver, the Treasury always
redeemed in gold, de facto supporting a gold standard system.

In order to guarantee the redemption of the notes, the Treasury had
two alternatives: (i) to use the surplus revenue or (ii) to issue bonds
of the kind authorized by the Refunding Act (July 14, 1870).[2]

The viability of the gold standard did not present any problems
during the 80's. In particular, between 1885 and 1890, a constant

government surplus guaranteed a large amount of gold reserves, well above the required minimum of $100 million.[3] The period of monetary instability started early in the 90's. The underlying cause of the precariousness of the period was excess money supply that was generated by two different sources:

(a) Between 1890 and 1893, the Sherman Act caused a steep increase in the paper component of the money supply, by forcing the Treasury to make huge monthly purchases of silver in exchange for a new kind of paper money (the Treasury Notes of the 1890's).[4]

(b) Starting in 1891, budget surpluses begun to decline and eventually, in 1893 and until 1896, they turned into deficits (see Figure 1). One of the principal cause of this deterioration in the government's accounts was the McKinley Tariff Act of 1890 which, by increasing some of the duties to prohibitory levels and by putting sugar (a major revenue producer) on the free list, seriously decreased customs receipts (see Figure 2). During this period the Congress did not allow any form of borrowing to finance the large and continuous deficits. The Treasury had the option of either monetizing the deficit by using previously accumulated legal tender, or by issuing the kind of bonds authorized by the Resumption Act, once the gold reserves had fallen below the minimum.[5]

During those years the viability of the gold standard became more and more uncertain; the Congress and the Treasury had to take various actions in order to avoid its collapse. The Sherman Act was repealed November 1, 1893 and the Treasury undertook four bond issues: in February 1894 ($50 million), in November 1894 ($50 million), in February 1895 ($62.3 million, plus approximately $20-25 million in lines

of credit), and in January 1896 ($100 million).

II Borrowing Operations and the Viability of the Gold Standard

This section presents a simple model which permits one to analyze the effects of foreign currency borrowing policies on the viability of a gold standard. An international gold standard, like the one prevailing in the 1890's, can be interpreted as a fixed exchange rate regime, where the fixed parities are given by the ratios of the gold content of the various currencies. Similarly, the gold reserves of the monetary authorities can be interpreted as foreign currency reserves. In the rest of the paper, we assume that the international economy is composed by two countries: a domestic economy (the U.S.), and a foreign economy (the U.K.)

Formally we can measure the viability of a fixed exchange rate system at time t with the probability that a speculative attack on the fixed parity will occur at time t+1. This probability function can be obtained from the following monetary model of the exchange rate for a small economy:[6]

(1) $m_t - p_t = \beta + \eta y_t - \alpha i_t + w_t$

(2) $i_t - i_t^* = E_t e_{t+1} - e_t$

(3) $p_t - p_t^* = e_t + u_t$

Here m, p, e, and y are the logarithms of money stock, price level,

exchange rate in dollars per pound and a measure of real activity; i is
the nominal interest rate and w and u are uncorrelated stochastic
disturbances. The parameters a, β, γ are all positive, and E_t is the
expectation operator conditional on information at time t. British
variables are marked with asterisks, and all variables are assumed to be
exogenous to the exchange rate. [7]

The model can be solved for the (shadow) flexible exchange rate:

$$(4) \quad e_t = \frac{1}{1+a} \sum_{j=0}^{\infty} \left[\frac{a}{1+a}\right]^j E_t h_{t+j}$$

where

$$(5) \quad h_{t+j} = \textbf{m}_{t+j} - \beta - \gamma y_{t+j} + a i^*_{t+j} - w_{t+j} - p^*_{t+j} - u_{t+j}$$

The money stock in a gold standard can be defined as the sum of two
components: (i) the gold in circulation plus the part of the paper
money backed by gold reserves in the Treasury and (ii) the silver in
circulation plus the paper money not backed by gold reserve, which I
defined as the domestic component of the money supply (DC_t).

The basic idea underlying the speculative attack literature is that
the fixed parity will be viable until it becomes profitable to collapse
it. This will happen as soon as the exchange rate expected to prevail
right after the speculative attack (the shadow exchange rate) exceeds
the given parity. [8] The level of the shadow exchange rate depends
critically on what kind of regime is expected to prevail once the gold
standard collapses. I assume that, in this circumstance, a standard in

which paper money is convertible into silver will be established.

In the post-attack regime, to which equations (1) - (5) refer, gold goes out of circulation. The money stock is given by the sum of the domestic component and the amount of reserves still in the Treasury after the collapse of the gold standard. By defining G^m to be the level of gold reserves at which the Treasury abandons the defense of the gold standard (5) can be rewritten as:

$$(6) \quad h_{t+j} = \log(DC_{t+j} + G^m) - \beta - \gamma y_{t+j} + ai^*_{t+j} - w_{t+j} - p^*_{t+j} - u_{t+j}$$

In this framework, the probability that a speculative attack will occur in the next period is given by:

$$(7) \quad \Pr\{ \frac{1}{1+a} \sum_{j=0}^{\infty} \left[\frac{a}{1+a}\right]^j E_t h_{t+j} \geq e\}$$

where e is the fixed parity. Borrowing, either foreign reserves (gold) or domestic currency, has the effect of reducing the post attack level of domestic credit and, consequently, it tends to reduce the probability of an immediate speculative attack. At the same time, however, borrowing raises the Treasury's debt obligations, which could lead to an expansion in future money creation, and thus to an increased probability of a collapse of the system. Buiter (1987) shows that, even in the case of a complete monetization of the future repayments, borrowing operations decrease the probability of an early collapse, and increase the probability that the collapse will occur in the long run. Also, under mild conditions, Buiter (1987) shows that the time interval

until the collapse is increased. In other words, it is always the case that borrowing allows the government to "buy extra time", during which more fundamental fiscal corrections could be implemented as, indeed, happened in the period under consideration. During the second part of the 1890's, in fact, several actions where taken in order to increase revenues: first in 1894 with the Wilson-Gorman Tariff Act, and then in 1897 with the Dingley Tariff Act (see Figures 1 and 2). Therefore, the bond issues undertaken by the Treasury between 1894 and 1896 should have enhanced the viability of the system in the short run.

If our interpretation of the facts is correct, the probability of a speculative attack on the gold standard between 1889 (the year in which our analysis starts) and 1896 should have followed a specific time pattern. In particular, the probability should start to increase gradually by mid-1890, when the Sherman Act was passed. It should then reach a peak around the end of 1893 when the Sherman Act was repealed. From 1894 to 1896 it should decrease back toward zero, and the reduction should be concentrated in discrete jumps occurring at the time of the borrowing operations. In order to verify the validity of our analysis, in the next section we estimate the probability of the collapse of the gold standard between January 1889 and December 1896.

III Estimating the Probability of a Speculative Attack

In order estimate the probability of a speculative attack we have to compute the expected shadow exchange rate, which is a function of all future expected h_{t+j}. The first step in our procedure will be to estimate the variables $E_t h_{t+j}$ for t=0,1,...T and j=0,1,... . This

requires estimates of the money demand function and an assumption about the value of G^{m}. In the following we assume that the Treasury will give up the defense of the parity once the gold reserves in its vault are completely exhausted (i.e. $G^{m} = 0$)

Since we are interested in computing the post-attack floating (shadow) exchange rate, we should be estimating the money demand function prevailing during the *post-attack flexible exchange rate regime*. Since the gold standard did not collapse, the only data available refers to the fixed exchange rate regime. However, the demand for cash balances need not be dependent on the particular exchange rate regime. On the contrary, it could be shown that under reasonable conditions this will not be the case.[9] I assume that this independence property holds, and I estimate the money demand equation (1) using monthly data in the period 1889:01-1896:12. Given the potential dependence of the domestic interest rate on the money supply process, consistent estimates were obtained by instrumental variables, using the British interest rate, the lagged domestic output and the lagged domestic interest rate as instruments[10]. The estimate of the money demand parameters are given in Table 1. All coefficients are significant and have the expected signs. The reported standard errors are consistent estimates obtained applying the White/Hansen correction. We can now compute an estimate of h_{t} using equation (6) under the assumption that $G^{m} = 0$. To estimate time t shadow exchange rate we also need to compute $E_{t} h_{t+j}$ for $j \geq 0$. In order to calculate these expected values, we must make some assumption about the stochastic processes governing the set of state variables included in h_{t}. A natural way to interpret h_{t} is as the difference between money supply (dc_{t}) and the

factors determining money demand (i.e. $md_t = \beta + \gamma y_{t+j} - \alpha i^{*}_{t+j} + w_{t+j} + p^{*}_{t+j} + u_{t+j}$). A crucial characteristic of the period under consideration is the change that took place in the domestic credit creation. Two major switches in monetary policy occurred in the 1890's: the approval and the subsequent repeal of the Sherman Act. Consequently, we decided to break the sample into three parts and to model dc_j in each period with different ARIMA processes. On the other hand, there is no reason to believe that an analogous shift occurred in the variables generating the post-attack md_j, i.e. output, foreign prices and foreign interest rate. Therefore, a unique ARIMA process for the whole period was estimated for md_j. The result of the time series identification and estimation procedure are summarized in Table 2, 3, 4 and 5. While dc_t appears to be AR(1) in all three sub periods, md_t is best approximated by a MA(1) process. In order to investigate the adequacy of the fitted processes, several statistics testing the correlation properties of the residuals are also provided. In particular, we report the standard Durbin-Watson statistic, the Q-statistic, the d'-statistic (King (1981)), the h-statistic (Durbin (1970)) and the L-statistic (Godfrey (1978) and Breusch (1978)). None of these tests rejects the hypothesis that the residuals are indeed uncorrelated.

Given the simple first order process representations for dc_j and md_j, it is possible to compute $E_t h_{t+j} = E_t dc_{t+j} - E_t md_{t+j}$ for $t=1889.01,\ldots,1896.12$ and $j=0,1,\ldots$. We now have everything necessary to compute the time series of the probability of attack, which is presented in Figure 3. The time pattern displayed by this probability confirms our theoretical analysis. The viability of the gold standard

was not a problem until August of 1890, as indicated by the probability of an attack being zero before that period. As our model predicted, the probability of collapse of the fixed exchange rate regimes increases during the three years following the approval of the Sherman Act, reaching a maximum in September 1893, right before the Act was repealed. Between May and August 1893 the probability of an attack is very volatile, a consequence of the bank panic which occurred during that period. Between 1894 and 1896 the probability decreases on average, with most of the decline occurring when the borrowing operations were undertaken.

IV On the Optimal Size of the Loan

In order to address the issue of the optimal amount of borrowing we have to identify the trade-off involved in borrowing international reserves. On the one hand, borrowing allows the monetary authorities to reduce the probability of a collapse of the fixed exchange rate regime, which is considered a valuable arrangement.[11]. On the other hand, the operation is costly in terms of interest payments and, more generally, in terms of possible increases in the interest rate induced by the bond issue. Formally, we can describe the problem of determining the optimal size of the loan as follows:

(P-1) $\quad \min_{B_t} \quad Pr(\ B_t)$

s.t. $PVC(\ B_t) \leq C_t$

where B_t is the amount of the loan, PVC(B_t) is the present value of the cost of the borrowing operation, and C_t is the maximum cost that the monetary authorities are willing to pay in order to guarantee the viability of the gold standard. In addition, in the environment under consideration there existed other constraints of institutional nature. Specifically, the Treasury was constrained in the choice of borrowing instruments by the Refunding Act (see footnote 2). Moreover, such borrowing could take place only in order to replenish gold reserves when they had fallen below their minimum level of $100 million.

How can we determine whether the borrowing policy of the Treasury during the 1890's was the outcome of an optimization process of the kind described above? A minimal test is to verify that the institutional constraints were satisfied. This was indeed the case: the type of bonds used were among the ones allowed by the Refunding Act and , at the time of the borrowing operations, the Treasury 's gold reserves were below $100 million (see Figure 4). In the following, we propose a more interesting way of investigating the rationale behind the behavior of the Treasury and the optimality of its actions. This will involve the use of information that is revealed by the particular circumstances in which the third issue (February, 1895) took place.

The bond issue of February 1895 is particularly intriguing because, in that episode, the Treasury used the services of a syndicate of private bankers. The terms of the agreement are stated in the contract that J.P. Morgan and August Belmont, as representatives of the syndicate, signed with the U.S. Treasury. The Belmont-Morgan contract stipulated the purchase of gold coins by the Treasury, in exchange for

30 year 2.4% bonds. The par value of the issue was $62.3 million. It was purchased by the syndicate at a price equivalent to 3.75% at par. In addition, and of most importance, the syndicate agreed that they "...so far as it lies within their power, will exert all financial influences and will make all legitimate efforts to protect the Treasury of the United States against withdrawals of gold, pending the complete performance of the contract."

With this provision the syndicate granted the Treasury a supplementary line of credit (in gold) for the duration of the contract.[12] Given that short term loans were not allowed, this additional borrowing took the form of an exchange of gold for paper money, with the natural understanding that the legal tender accrued as the result of this operation would not have been used by the syndicate to attack the Treasury's gold reserves. The fact that this legal tender was hoarded for the most part abroad, implied that the level of domestic credit would not be affected. In other words, this line of credit was de-facto equivalent to a bond issues. One of the interesting aspects of the Belmont-Morgan contract, which will be discussed below, is the way in which the monetary authorities arranged to pay the interest on this loan. Throughout the duration of the contract, the syndicate delivered between $20 and $25 million in gold to the Treasury, in exchange for legal tender. The whole operation, therefore, guaranteed the Treasury both long term financing, i.e. the 30 year bonds, and short term financing, i.e. the line of credit.

Note that the contract has the characteristic of a "firm commitment" contract, one by which the investment banker underwrites the entire issue, guaranteeing to the issuer a fixed amount of funds.

However, the choice of this contract, instead of other alternative forms like "best effort," was made for other reasons in addition to the insurance advantage. It is quite possible that the Treasury expected to be able to market the issue directly, at a price higher than the one agreed upon with the syndicate. The spread not only compensated the syndicate for undertaking the risk and for the distribution efforts, but was also a way to pay for the line of credit. This form of contract enabled the Treasury to secure short term financing without obtaining an explicit approval from the Congress, which it was not willing to concede.

Following the approach taken above, we view the Belmont-Morgan contract as the result of an optimization problem that the Treasury had to solve in order to assure the practicability of the gold standard. In addition to the constraints we mentioned before, the Treasury had to guarantee a minimum level of profit to the syndicate, in order to compensate it for underwriting the bond issue and for providing the line of credit. Recalling that the probability of a speculative attack is a monotonically decreasing function in the amount of gold borrowed, we can express the optimization problem as:

$$(P-2) \quad \max_{N, G^C} \quad p'N + G^C$$

$$\text{s.t. (a) } \tau = [p(N) - p']N - I(G^C) \geq K$$

$$\text{(b) } G_0^T < 100$$

$$\text{(c) } r \leq r_{max} \text{ (or } p' \geq p'_{min})$$

where N and G^C represent the number of one dollar bonds in the issue and the dollar amount of line credit respectively; τ is the profit of the syndicate; p, a function of N, is the price at which the bond is purchased by the public and p' is the price at which it is underwritten by the syndicate; I, a function of G^C, is the cost of providing the line of credit; K is the minimum level of profit required by the syndicate in order to perform the services; G_0^T is the level of gold reserves in the Treasury before the contract was signed; r is the interest rate at which the bond issue is underwritten and r_{max} is its maximum possible level. In writing constraint (c) we assumed that the cost of the borrowing operation can be approximated by the interest paid on the loan. Note that, given the characteristics of the bond (i.e.30 years @ 4%) and assuming that the last constraint holds with equality, the knowledge of r_{max} implies the knowledge of p'_{min}, and vice versa. The maximum allowed yield of the operation has been implicitly revealed by the contract itself to be $r_{max}=3.75$, and we take it as a given parameter.

In order to determine whether the behavior of the Treasury was consistent with this interpretation of the facts, we solve the above optimization problem, derive the "optimal contract" as prescribed by our theory, and compare it with the actual Belmont-Morgan contract.

The solution of P-2 requires an estimate of constraint (a) which, in turn, requires information about the demand for Treasury bonds, $p(N)$, about the costs of providing the line of credit, $I(G^C)$, and about the amount of profits, K, that the syndicate intended to make.

IV.A The Demand for Treasury Bonds

To derive the relationship between the size of the bond issue and
the price at which it could have been distributed by the syndicate, the
following strategy was used. As mentioned in section I, in November
1894 the Treasury issued a $50 million, 10 year bond @ 5%, to replenish
the gold reserves that had fallen below the required minimum of $100
million. All the bids made for the bond are recorded in the report of
the investigation conducted by the Committee on Finance in 1896. [13]
With these data, the demand function faced by the Treasury on that
occasion can be traced out, and it is presented in Figure 5.

In addition to this function, the report provides an additional
piece of information. In particular, it reveals that a syndicate of
bankers, J. P. Morgan among them,[14] made two separate bids for that bond
issue. They offered to purchase the whole issue at a price of 1.17077
per $1 par value, or to purchase any part of it at 1.168898. Note,
however, that if the syndicate expected to face the same demand function
that the Treasury was facing, it would have incurred a loss by acquiring
the whole issue at 1.17077, since the equilibrium price along the
Treasury demand curve was 1.16306. If we assume that the syndicate was
behaving rationally, we have to conclude that it expected a larger
demand for the bond than the one faced by the Treasury.

The reason for this difference is that the individuals may have had
an incentive to report a price to the Treasury that was lower than their
true reservation price. This is because of the particular structure of
the auction used to allocate the issue. The Treasury, in fact, was
adopting a discriminating auction, in which the bonds were assigned at

the price bid, starting from the highest bid and working downward until the whole issue was allocated. Under a discriminating auction, the mean and the variance of the bids are lower than they would be under competitive auction, under which the agent reveals his true reservation price.[15] This implies that the demand curve derived from the bids to the Treasury has to be flatter and have a lower intercept than the true demand curve, which the syndicate expected to face. Despite the fact that the actual allocation mechanism used by the syndicate is not known, a close examination and review of the journals of the time suggests that competitive auction was utilized.[16]

We must recover the actual demand faced by the syndicate, a demand different from the one faced by the Treasury. Knowledge of this syndicate's demand function will be used to construct an estimate of the demand faced by the February 1895 syndicate. Since the two issues occurred within 10 weeks of each other, we can make the reasonable assumption that the market demand did not change in such a short period of time. As a result, after accounting for the fact that part of this demand ($50 million) was satisfied by the November issue, we can consider it to be the demand for the February 1895 bond as well.

The demand function has to pass through the price at which the syndicate sold the November 1894 issue (1.19).[17] This condition, with an assumption of linearity (i.e. we assume $p(N) = a - bN$), identifies a set of possible demand curves. This set can be further narrowed by recognizing the existence of a maximum price that any individual would be willing to pay for the bond. The maximum price has to be equal to or less than 1.24, which corresponds to a yield of 2.3%, the interest rate of British consols, that were expressly payable in gold. Moreover, the

maximum price has to be greater than or equal to 1.21, which correspond to the slope of the linear approximation of the Treasury's demand function. This condition guarantees that the Syndicate's demand function is steeper than the one faced by the Treasury. The set of these demand curves is represented by the shaded area in Figure 6. The contracts corresponding to different demand curves in this family will be computed to see if any of them support the actual Belmont-Morgan contract as an optimal outcome.

IV.B The Syndicate's Expected Profit

The report on the November 1894 issue also contains information that can be used to identify the level of profit that the syndicate intended to earn, as a return on the underwriting services that it provided. If the Treasury had accepted the "all or nothing" bid, the syndicate's expected profit would have been:

$$(8) \quad K_1 = (p(N_1) - p_1)N_1$$

where p is the expected demand function faced by the syndicate, N_1 is the size of the issue ($50 million), and p_1 is the price offered by the syndicate for the "all or nothing" arrangement. K_1 is given by the area p^*ABp_1, in Figure 7. If, instead, the Treasury had accepted the "all or any part" offer, the syndicate profit would have been:

$$(9) \quad K_2 = (p(N_2) - p_2)N_2$$

where N_2 is the number of one dollar bonds that the Treasury would allocate to the syndicate, and p_2 is the price offered by the syndicate under the "all or any part" arrangement.[18] K_2 is given by the area EACD in Figure 7. Note that the price at which the syndicate is able to sell the bonds it underwrites is the same under the two arrangements, that is $p(N_1)=p(N_2)=1.19$. If we assume that the syndicate profit is a linear function of the number (in millions) of underwritten securities,[19]

(10) $K_i = k_0 + k_1 N_i$ $i = 1, 2$

equations (8) and (9) can be solved to obtain $k_0 = 0.19$ and $k_1 = 0.015$. k_0 and k_1 are in the same units as K_i, i.e. in millions of dollars.

IV.C The Cost of Providing the Line of Credit

The last piece of information needed to solve the maximization problem is an estimate of the cost of providing the line of credit. By providing the line of credit, the syndicate lost the opportunity to earn the interest that is obtainable by lending the gold on the London market. The cost of the operation in terms of the interest loss is $i_6^* G^c$, where i_6^* is the six month interest rate in London.[20]

The syndicate, in addition to the interest loss, was also bearing a second cost component, i.e. the capital loss that it expected in case the gold standard collapsed. If the Treasury were forced, by a speculative attack, to abandon the defense of the parity, the dollar would have been devalued vis-a-vis the pound, thus increasing the price

of gold. Since the syndicate, in providing the line of credit, was exchanging gold for dollars with the Treasury, it would have suffered a loss proportional to the size of the devaluation. This expected capital loss, plus a possible risk premium, is given by the spread between the domestic and foreign interest rates, and it is represented by the interest parity condition. Therefore, the total cost of providing the line of credit can be approximated by $i_6 G^C$, where i_6 is the domestic, six month interest rate.

IV.D Solving the Maximization Problem: The Belmont-Morgan Contract

We can now rewrite the problem P-2 as:

(P-3) $\max_{N, G^C} \ p'N + G^C$

s.t. (a) $r = [p(N) - p']N - I(G^C) \geq K$

   (a1) $p(N) = a - bN$

   (a2) $I(G) = i_6 G^C$

   (a3) $K = k_0 + k_1 N$

Substituting (a1), (a2) and (a3) into (a) and solving for G^C we obtain:

(11) $G^C = \dfrac{(a - bN)N - p'N - k_0 - k_1 N}{i_6 + k_1}$

which can be used to solve P-3 as an unconstrained maximization in term of N. The first order condition, can be solved to give:

(12) $N = (a - k_1 - p'(1 - i_6 - k_1)) / 2b$

and, from (11) we can recover the optimum for G^C:

(13) $G^C = (i_6+k_1)^{-1}\{[((a-k_1-p')^2 - (p'(i_6+k_1))^2) / 4b] - k_0\}$

By substituting into (12) and (13) the values of the parameters
derived in the previous sections, we obtain the optimal values of N and
G^C corresponding to different demand functions in the permissible set
described above. The results are reported in Table 6. Here b is the
slope of the linear demand functions[21], N and G^C are in millions of
dollars; and p(62.3) is the price implied by each demand curve, given
that N=62.3. The values of b=0.0004 and b=0.001 represent the
boundaries of the feasible set. However, since the syndicate actually
sold the issue at approximately 1.125,[22] we can confidently concentrate
our attention on the bottom part of Table 6. Recall that in the actual
contract N was $62.3 million and G^C was at least $20 million.
Therefore, our analysis produces a set of simulated contracts which are
quite similar to the Belmont-Morgan contract. We interpret this result
as evidence that the Treasury's borrowing policy of the 1890's was
motivated by the desire of maintaining the gold standard and that, in so
doing, it behaved in an efficient way.

V **Conclusions**

This paper analyzes the behavior of monetary authorities when
facing an imminent collapse of the exchange rate. In particular, the

paper studied the effectiveness of borrowing international reserves to avoid devaluations. The attention was focused on a particular episode, i.e. the exchange rate crisis of 1894-96. We concluded that borrowing policies are effective in avoiding temporary exchange rate crises, and that the specific borrowing policy followed by the U.S. Treasury in that event was not only effective but also optimal when considered in light of the economic environment and the set of institutional and political constraints that it was facing.

Nowadays, the procedure of borrowing from private bankers has been replaced by the practice of obtaining lines of credit from foreign monetary authorities (central banks). These lines of credit are shorter term than the formal long term loan introduced in the episode considered. In this respect, they are similar to the line of credit implict in the Belmont-Morgan contract. It is interesting to note, however, how the basic mechanism of obtaining these short-term lines of credit is still in operation. In fact this kind of device is institutionalized in exchange arrangements like the EMS where private banking syndicates are replaced by the pool of the central banks participating in the system. A natural extension of this analysis is to study the timing and the size of the borrowing of international reserves which occurred in more recent years, in particular during the working of Bretton Woods and of the European Monetary System.

Data Appendix

1.   The money stock is given by the sum of : (i) gold coins and gold
certificates in circulation, (ii) silver dollars, subsidiary silver
coins and silver certificates in circulation and (iii) Treasury Notes,
U.S. Notes (greenbacks), National Bank Notes and Currency Certificates
in circulation. All Monetary aggregates are taken from the National
Monetary Commission (1910).

2.   The domestic component of the money supply has been computed by
subtracting the gold, gold certificates in circulation, and the gold
reserves in the Treasury from the total money stock in circulation.

3.   The U.S. price index is the Warren & Pearson price index from
"Index Number of the Wholesale Prices of all commodities, 1720 to 1932,"
in Warren and Pearson (1933), Table 1 pg. 10.

4.   The U.K. price index is the Sauerbeck price index from "Monthly
Fluctuations of the Index Number of Forty-Five Commodities," in
Sauerbeck (1895) and (1897).

5   As a measure of the level of activity, I used bank clearings
outside New York City, from Macaulay (1938), Table 27. Bank clearings
represent dollar totals of checks and drafts drawn on individual banks
and credited to the accounts of other banks through the city clearing
house association to which the individual bank belonged. New York
City's large volume of bank clearings is attributable to financial

transactions that largely reflect stock and bond transactions. As a result, bank clearings outside New York City are a more reliable indicator of the movement in output and trade than total clearings.

6.   The U.S. nominal interest rate is the interest rate on call loans; the U.K. interest rate is the interest rate allowed for deposits at call by Discount Houses, from the National Monetary Commission (1910) and the Commercial and Financial Chronicle, various issues.

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Endnotes

1 For a more detailed analysis of the period, see Garber and Grilli (1985), and Simons (1968).

2 The Refunding Act authorized the Treasury to issue three different kinds of bonds: (1) 10 year @ 5% (2) 15 year @ 4.5% (3) 30 year @ 4%.

3 This lower bound for the gold reserves originated in the Act of July 12, 1882 which established that any time the gold reserves of the Treasury fell below $100 million, the Treasury had to suspend the issuing of gold certificates. After that, $100 million was considered to be the minimum level of the gold reserves in the Treasury, as set down by the Judiciary Committee of the House of Representatives in a report submitted on July 6, 1892. The report stated: "That it was the intention of the Congress to fix the minimum amount of this reserve fund at $100 million gold and gold bullion, and that it should be maintained at that sum, seems clear from the language of the Act [of 1882]."

4 The Sherman Silver Purchase Act was passed on July 14, 1890.

5 Note that, by the Act of May 31, 1878, the Treasury was forbidden to cancel or retire any of the U.S. notes then outstanding.

[6] This model has been widely used in speculative attack literature. For a more detailed explanation of solutions to these types of models, see Flood and Garber (1984a), Blanco and Garber (1986) and Grilli (1986).

[7] The actual form of equation (3) that we used in the empirical section is:

$$p_t - p_t^* + k = e_t + u_t$$

where k is constant such that mean(e)=mean (p-p*+k). This is to make the price levels, which are index numbers, compatible with the exchange rate which is in $/£.

[8] We are referring to a buying attack, i.e. when speculators buy foreign reserves (gold) from the monetary authorities, expecting to profit from a devaluation of the domestic currency. For a model in which selling attacks, i.e. attacks aiming to profit from a revaluation of the currency, are also considered, see Grilli (1986).

[9] Penati and Pennacchi (1986), for example, show that this type of independence holds if the representative agent has a separable logarithmic utility function in consumption and real cash balances.

[10] In the appendix we provide a detailed description of the data.

[11] Here we do not elaborate on why this might be the case. A paper that discusses the optimality of fixed exchange rates is Mundell (1973).

[12] The duration of the contract was implicitly fixed at six months. The contract had additional minor provisions that will not be expressly considered in the present paper. For a discussion, see Garber and Grilli (1985).

[13] The Committee was appointed to investigate the Treasury bond sales that occurred during the years 1894-96.

[14] Contrary to the Belmont-Morgan syndicate, the composition of this syndicate is known. Even if we cannot be certain about it, it is very likely that most of the members of the syndicate of November 1894 were also members of the February 1895 syndicate.

[15] These results can be found in Vickrey (1961), Smith (1966), and Harris and Raviv (1981), among others.

[16] Commercial and Financial Chronicle, February 1895.

[17] Commercial and Financial Chronicle, December 1, 1894.

[18] The value of N_2=50-16.5=33.5, where 16.5 is the quantity of bonds on the Treasury demand function, corresponding to p_2.

[19] This linear form is often used in actual contracts. See Mandelker and Raviv (1977).

[20] Note again that six-months was the duration of the contract, i.e. the period during which the syndicate had to provide the line of credit.

[21] Remember that the intercept is the same for all demand functions, and it is equal to 1.19, i.e. the price at which the issue of November 1894 was sold by the Syndicate.

[22] Commercial and Financial Chronicle, February 1895.

TABLE 1

MONEY DEMAND ESTIMATE: JANUARY 1889 - DECEMBER 1896

Instrumental Variables Estimates[†]

Parameter	Estimate	Standard Error[‡]
β	4.770	0.719
γ	0.663	0.156
α	0.023	0.006

[†] British interest rate, lagged domestic output and lagged domestic interest rate were used as instruments.

[‡] Consistent estimates of the standard errors were obtained using White/Hansen procedure.

TABLE 2

ESTIMATES OF dc$_t$ PROCESS

January 1889 - August 1890
(standard errors in parenthesis)

a$_1$	a$_2$	σ
0.359	0.945	0.009
(0.560)	(0.085)	

DV	d'	q(9)[1]	H	L(1)[2]	L(2)[2]
1.935	1.977	8.897	0.157	0.003	1.012
(1.411)[3]	(1.532)[4]	(<45%)[5]	(<87%)[5]	(<96%)[5]	(<60%)[5]

[1] In parenthesis is the number of autocorrelations used.

[2] In parenthesis is the order of the AR and MA against which the hypothesis of uncorrelated errors is tested.

[3] 5% significance point of d$_u$.

[4] 5% significance point of d$'_u$.

[5] Level of significance of the Test

TABLE 3

ESTIMATES OF dc_t PROCESS

September 1890 - October 1893
(standard errors in parenthesis)

a_1	a_2	σ
0.323	0.954	0.012
(0.178)	(0.026)	

DV	d'	$Q(17)$ [1]	H	$L(1)$ [2]	$L(2)$ [2]
1.550	2.101	15.22	1.405	0.101	0.780
(1.535) [3]	(1.595) [4]	$(<58\%)$ [5]	$(<16\%)$ [5]	$(<75\%)$ [5]	$(<68\%)$ [5]

[1] In parenthesis is the number of autocorrelations used.

[2] In parenthesis is the order of the AR and MA against which the hypothesis of uncorrelated errors is tested.

[3] 5% significance point of d_u.

[4] 5% significance point of d'_u.

[5] Level of significance of the Test

TABLE 4

ESTIMATES OF dc_t PROCESS

November 1893 - December 1896
(standard errors in parenthesis)

a_1	a_2	σ
0.734	0.893	0.019
(0.449)	(0.065)	

DV	d'	$Q(17)$[1]	M	$L(1)^2$	$L(2)^2$
2.127	2.142	20.50	-0.427	0.23	0.930
(1.535)[3]	(1.595)[4]	$(<25\%)$[5]	$(<67\%)$[5]	$(<64\%)$[5]	$(<63\%)$[5]

[1] In parenthesis is the number of autocorrelations used.

[2] In parenthesis is the order of the AR and MA against which the hypothesis of uncorrelated errors is tested.

[3] 5% significance point of d_u.

[4] 5% significance point of d_u'.

[5] Level of significance of the Test

TABLE 5

ESTIMATES OF $\mathbf{md}_t$ PROCESS

January 1889 - December 1896
(standard errors in parenthesis)

θ_1	θ_2	σ
5.55	0.311	0.108
(0.178)	(0.026)	

DW	d'	$q(26)^1$	M	$L(1)^2$	$L(2)^2$
1.927	1.950	25.11	1.32	0.65	3.894
$(1.690)^3$	$(1.710)^4$	$(<50\%)^5$	$(<19\%)^5$	$(<42\%)^5$	$(<14\%)^5$

[1] In parenthesis is the number of autocorrelations used.

[2] In parenthesis is the order of the AR and MA against which the hypothesis of uncorrelated errors is tested.

[3] 5% significance point of d_u.

[4] 5% significance point of d'_u.

[5] Level of significance of the Test

TABLE 6

OPTIMAL CONTRACTS

b	N	G^C	p(62.3)
0.0004	140.39	55.17	1.16508
0.0005	112.31	43.10	1.15885
0.0006	93.60	35.05	1.15262
0.0007	80.22	29.30	1.14639
0.0008	70.20	24.99	1.14016
0.0009	62.40	21.64	1.13393
0.001	56.15	18.96	1.12770

FIGURE 1
GOVERNMENT SURPLUS
(Millions of Dollars)

SURPLUS

YEAR

Source: National Monetary Commission
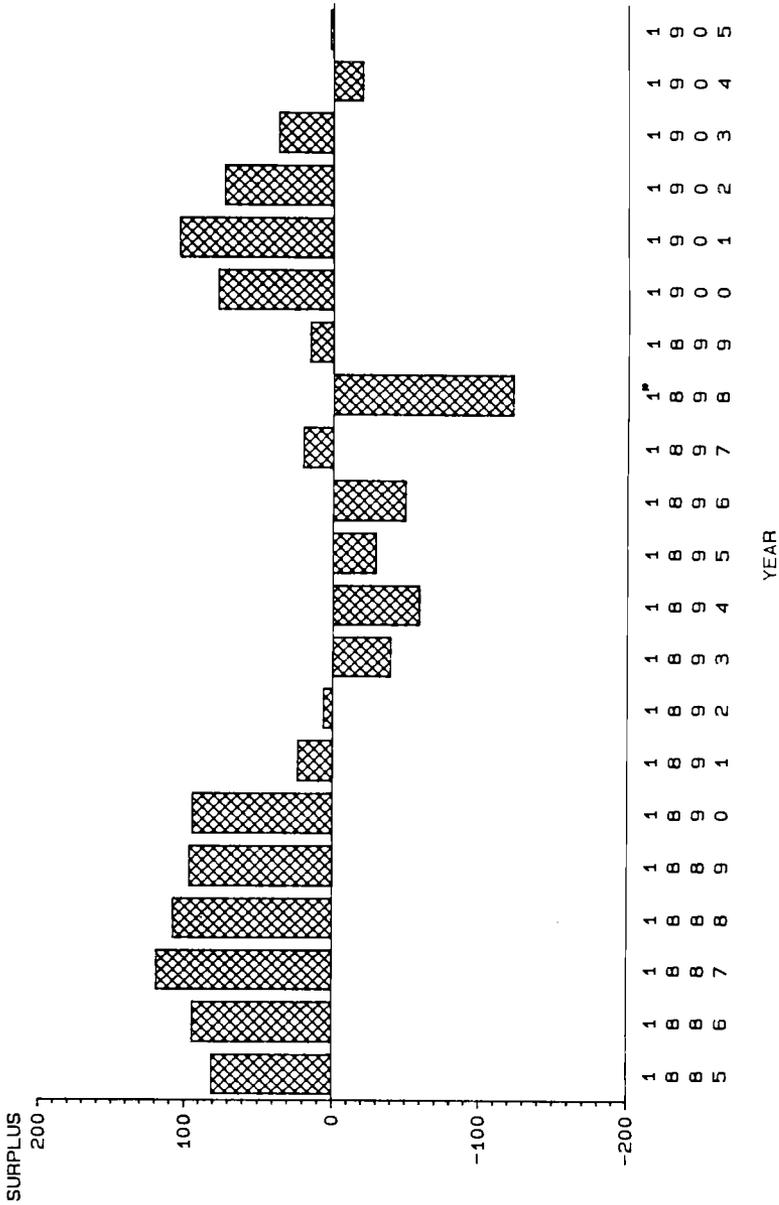
* Spanish-American War
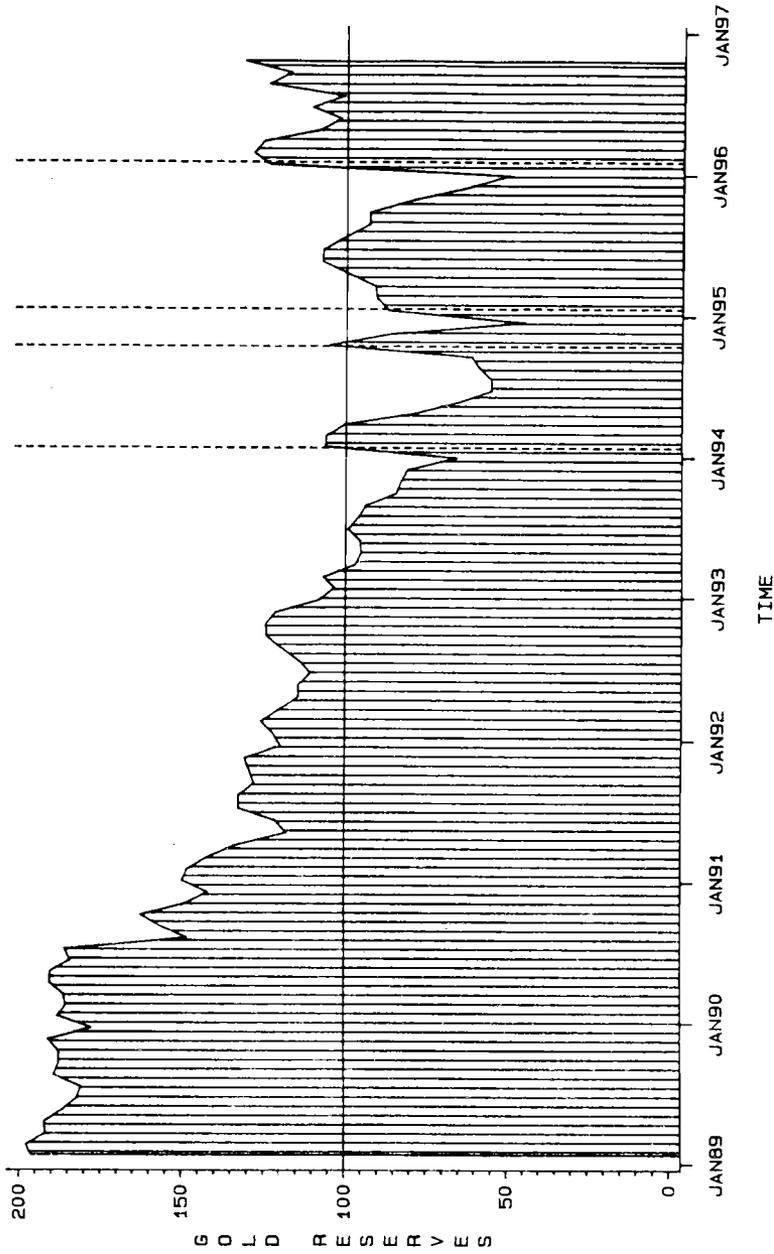
FIGURE 2
CUSTOMS RECEIPTS
(Millions of Dollars)
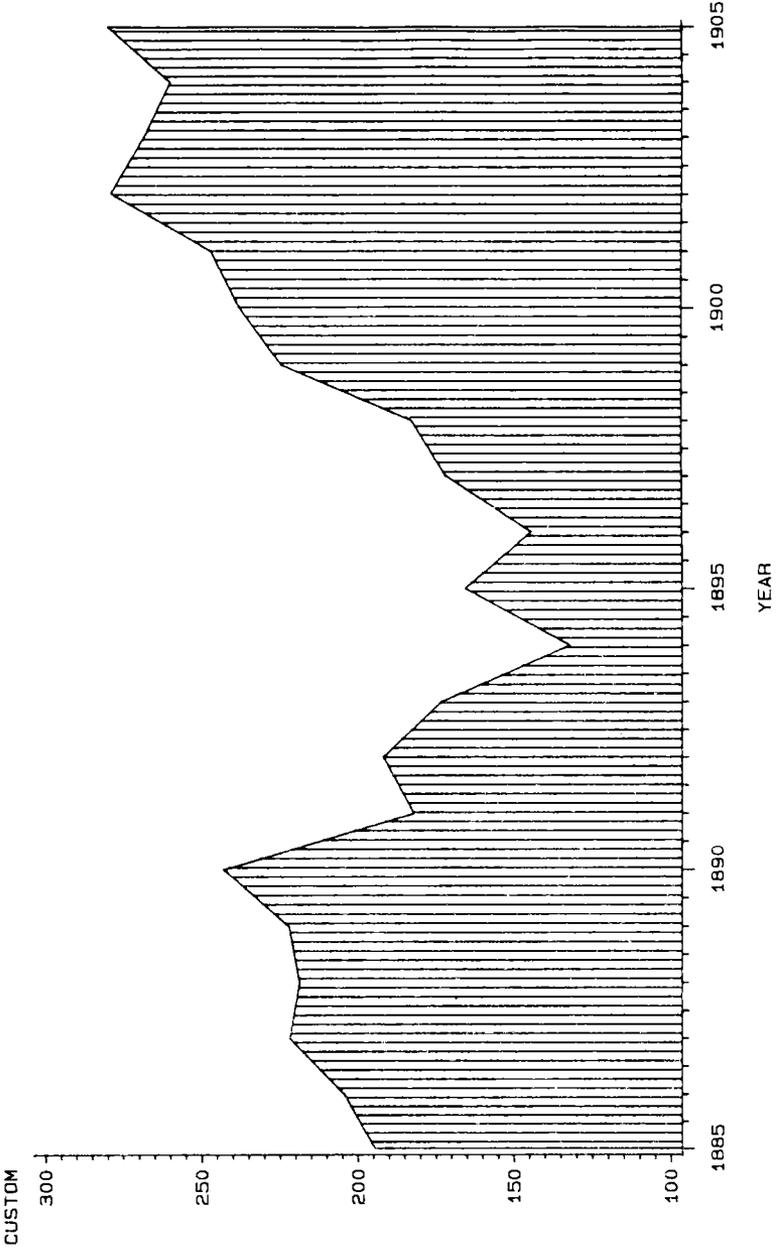
Source: National Monetary Commission

FIGURE 3
PROBABILITY OF A SPECULATIVE ATTACK
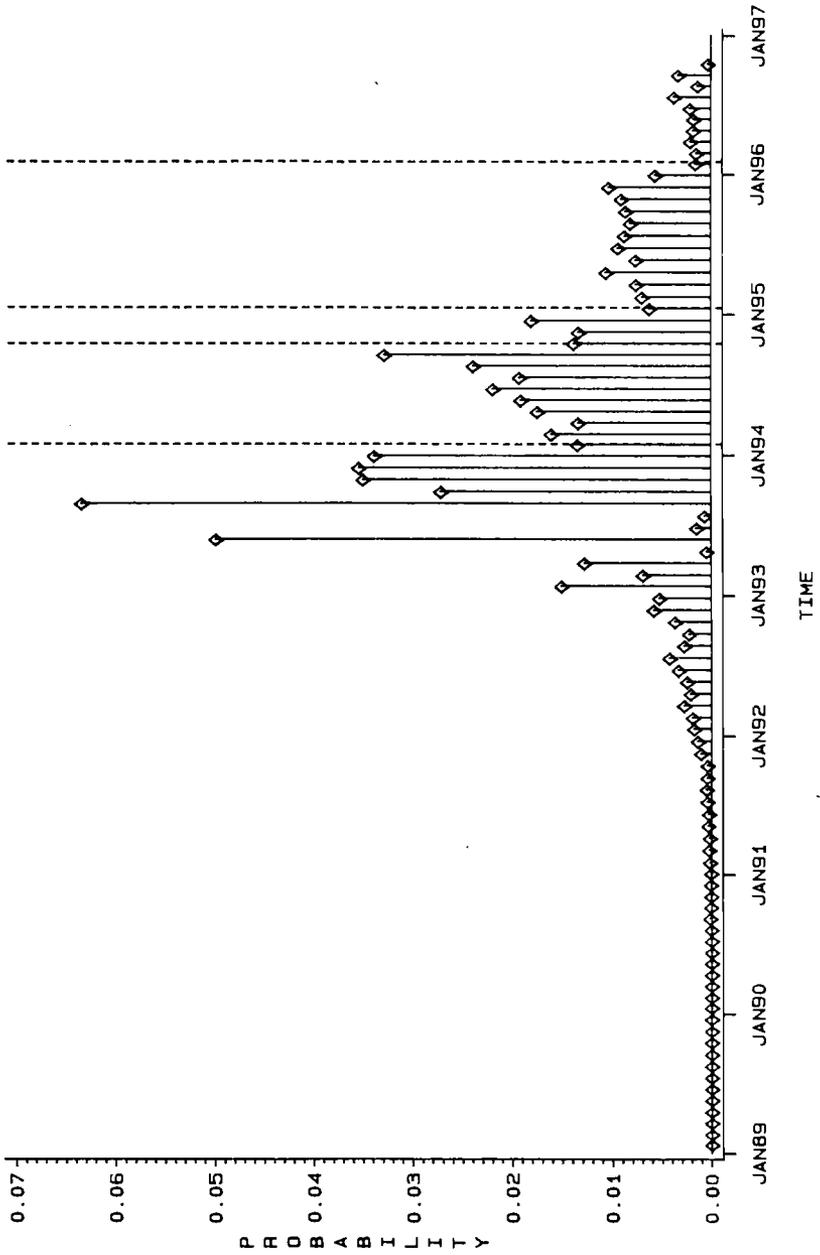
FIGURE 4
NET GOLD RESERVES IN THE TREASURY
(Millions of Dollars)

TIME

Source: National Monetary Commission

FIGURE 5
DEMAND FACED BY THE TREASURY
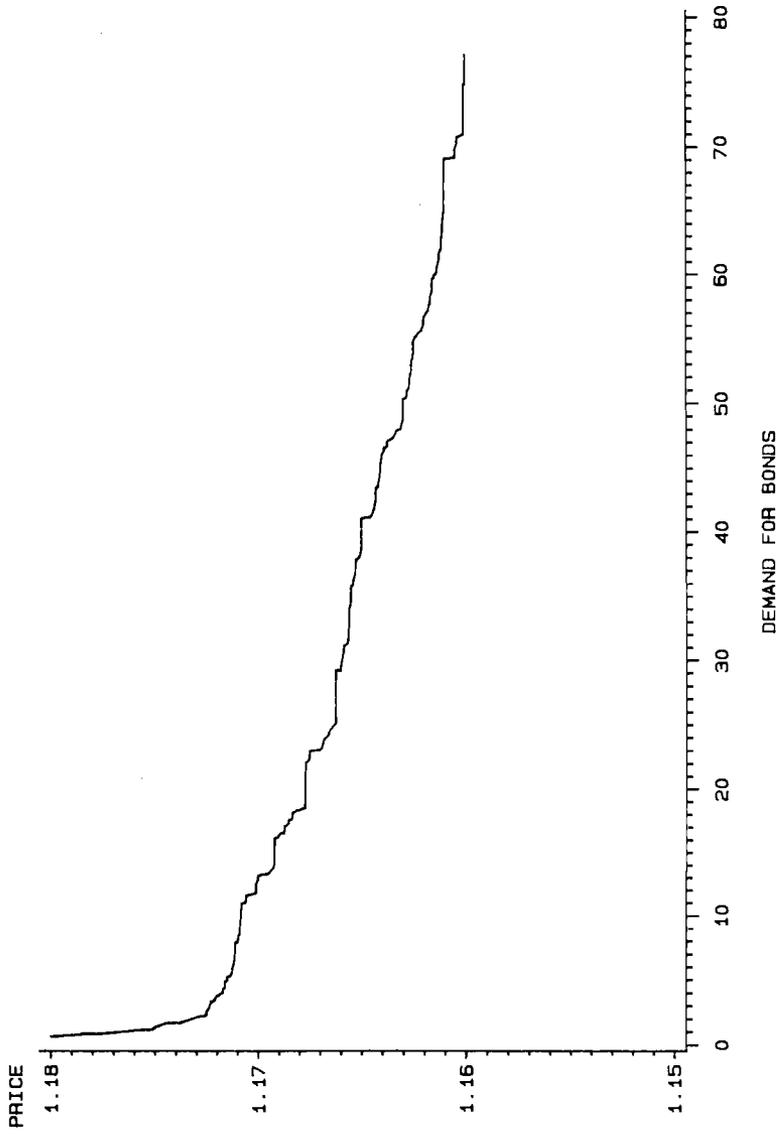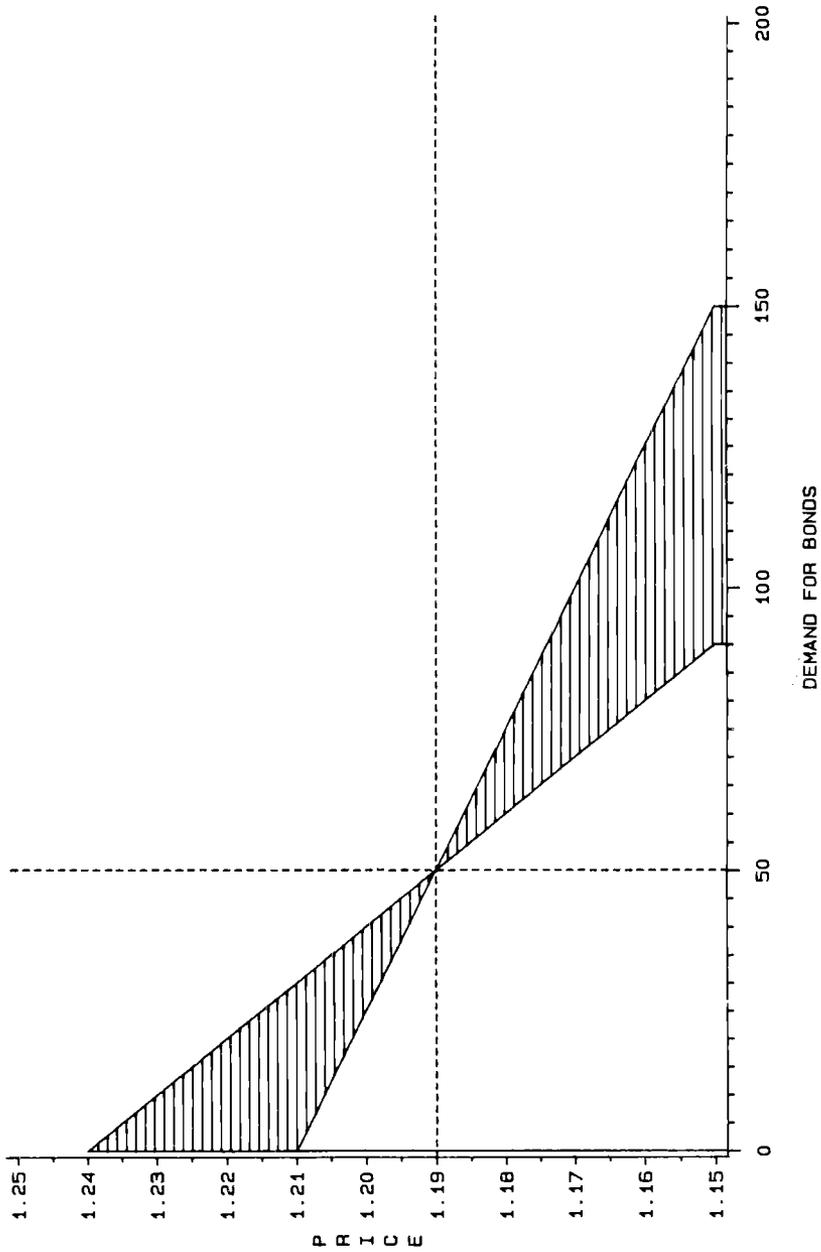(Millions of Dollars)

PRICE

DEMAND FOR BONDS

FIGURE 6

FEASIBLE SET OF DEMAND CURVES

FIGURE 7
SYNDICATE PROFIT